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EARLY CALEDONIAN EVENT IN THE PRE-ALPINE METAMORPHIC SEQUENCES OF THE ROMANIAN CARPATHIANS

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ABSTRACT

An Early Caledonian event is to be recognized in the Romanian Carpathians, its evidence being based on palynological data, radiometric ages and structural unconformities. The main proof consists in the break of sedimentation, post-dating an older metamorphism of formations belonging to the lower structural stage occurring at some point during the Ordovician.

INTRODUCTION

The Carpathian-Balkan mountain belt of South-Eastern Europe, of Alpine age, displays an intricate nappe structure, less complicated admittedly than the Alps themselves. In this belt, almost all the pre-Late Carboniferous deposits are more or less intensively metamorphosed; even a part of the Mesozoic deposits were subjected to a slight metamorphism. The metamorphic piles, together with their Mesozoic sedimentary cover, are involved in the nappe structure. This intensive fragmentation by the nappes — and by younger fault systems — together with the multiplicity of the superposed structural and metamorphic events within the crystalline sequences themselves, lead to the fact that the recognition of an Early Paleozoic tectonic cycle was highly difficult in these regions.

Evidence on the presence of an Early Caledonian (Finnmarkian) event within the metamorphic piles exposed in South-Eastern Europe is based on palynological data, on radiometric ages and on structural unconformities.

STRUCTURAL FRAMEWORK

The main structural units including metamorphic rocks of Late Proterozoic-Early Paleozoic age are the following (SĂNDULESCU, 1984).

1) Internal Dacides (northern Apuseni Mountains), with their north-western prolongation, the Tatric, Veporic and Gemeride nappes of the West Carpathians (Ostalpin) in Slovakia.

2) Median Dacides of the East and South Carpathians, including the Central East Carpathian nappes, the Supragetic and Getic nappes, with their southern prolongation into Serbia (north-eastern Yugoslavia) and Sredna Gora (Bulgaria). The Serbo-Macedonian massif could perhaps be considered as included in the Supragetic nappes or could rather have a higher, more internal position.

3) Marginal Dacides of the South Carpathians (Lower and Upper Danubian units), together with the Stara Planina Unit in the Balkans (Bulgaria).

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In contrast with other structural units (Pienides, Moldavides), the Dacides have in common the Late Cretaceous age of their tectogenesis. They are made up of superposed nappes advancing from the interior of the Carpathian-Balkan belt towards its exterior (northwards, eastwards or southwards).

GENERAL STRUCTURAL EVOLUTION OF THE CRYSTALLINE SCHISTS

Geological research undertaken during the last three decades in the metamorphic basement of the Carpathian-Balkan ranges (South-Eastern Europe) has shown that the pre-Upper Carboniferous crystalline schists building up the cores of these mountains have to be divided into three major supergroups.

The uppermost one may be called Variscan Supergroup. Its main characteristics may be summarized as follows: low-grade metamorphism; frequent appearance of metaconglomerates at different levels, and of massive limestones and dolomites in the upper parts; presence of basic metavolcanic formations, sometimes (bimodal magmatism) associated with acid ones; only a few granitic bodies emplaced. Sporo-protistologic research resulted in according an Ordovician-Lower Carboniferous age to this group. K/Ar ages of rocks included in this group were exclusively Variscan ($\leqq$350 m.y.).

The median supergroup was called "Marisian" by KRÄUTNER (1980). Its main characteristics are: low to medium-grade metamorphism (epidote-amphibolite facies, almandine zone) followed by a retrogressive chlorite event; extensive presence of a basic metavolcanic formation, followed by an acid one; widespread granitie intrusive activity in many regions. Microfloristic research yielded Upper Proterozoic-Cambrian palynomorphs; geochronologic studies gave a series of 400—500 m.y. K-Ar ages, besides a large number of Variscan ones.

The lower supergroup was called "Carpian" by KRÄUTNER (1980). Medium- to high-grade metamorphism was accompanied locally by migmatization; pegmatites are frequent. Almost no K-Ar ages from 600 m.y. upwards were obtained. Mycrophytological research is unconclusive. Opinions differ widely regarding this supergroup: basement of the Marisian, the two being separated by a structural and metamorphic discordance; lateral or downward gradual transition from the former.

The purpose of the present paper is to analyze the relations between the Variscan and the Marisian supergroups, leading to the conclusion that this very important and conspicuous discordance represents an Early Caledonian (Finnmarkian) event.

General features of the Marisian (Vendian-Cambrian)

In the Alpine territory of South-Eastern Europe dated Cambrian formations are known only from the Carpathians and the Balkans. All formations assigned to the Cambrian consist of low-grade metamorphic rocks (greenschist facies), down to the almandine isograd. Rocks of higher metamorphic degree have systematically been regarded as Precambrian in age, although, as already supposed by ANDRUSOV 1968), some metamorphic rocks from areas subjected to intense Variscan diastrophism (basement of the Tatro-Veporids) might be Lower Paleozoic in age. An abundant granitic magmatism was emplaced in the Marisian formations.

The Cambrian age assigned to several "epimetamorphic" formations of the Carpathians and the Balkans is mainly supported by palynological evidence. The only Cambrian macrofossils so far reported are Archeocyathids found near the

Dubocane village, in eastern Serbia (KALENIĆ, 1966). Some of the listed assemblages of palynomorphs from the "epimetamorphic" formations of the Carpathians are claimed to be of diagnostic value for the Upper Precambrian or Riphean *(sensu lato)*, others — either for the Lower Cambrian or for the Middle-Upper Cambrian. Many forms have a uniform distribution throughout the Upper Proterozoic and the Lower Cambrian.

An increase in the frequency and diversity of the Acritarchs from the Holmia Zone onwards, as well as the explosion of Ellipsoidomorphids in the Middle Cambrian seem actually to be the most reliable microfloristic changes to be used in biochronologic correlation.

General features of the Variscan

Variscan piles of metamorphic rocks constituting fairly well established lithostratigraphic sequences which, together, build up an upper structural stage of the crystalline basement, are known from almost all the structural units of the Carpathians and the Balkans. Their metamorphism was low-grade (or even very low-anchizonal). Metapsephites are frequent in lithologic sequences, mainly at the basis of the transgressive ones. Granitic intrusions crossing the Variscan formations are scarce in some regions, sometimes they are definitely absent (but in Slovakia they seem to be well represented). Radiometric ages of these formations are exclusively Variscan.

In contradistinction to the Alps, where the boundary between the "Altkristallin" and the "Jungkristallin" divides the Alpine structural stage from the Variscan and the Pre-Variscan, in the Carpathians and the Balkans the former includes only the Pre-Variscan (*i.e.* Caledonian and possibly earlier structural stages) whilst the latter is built up of Variscan and, when present, Alpine metamorphites.

The purpose of the present paper being the analysis of the Caledonian event in the Romanian Carpathians, the description of the Variscan will include only the lowest lithostratigraphic units and those assigned to the "Caledonian Era", the Ordovician, Silurian or the basis of the Devonian.

I MARGINAL DACIDES

1) Danubian

a) Marisian. In the Stara Planina Zone of the Balkans, a Late Precambrian (Riphaean) to Early Cambrian age has been assigned to the so-called Diabase-Phyllitoid Formation (DPF), which consists of mafic rocks, metakeratophyres, basic tuffogenic and tuffitogenic phyllites, metagreywackes and arkosic metasandstones (VRÎBLENSKI *et al.*, 1963). The stromatolitic marbles outcropping in the Bela Reka antiform of the Poréc Zone are considered to represent the upper member of this formation. It is from the top of the stromatolitic marbles that Archaeocyathids listed as Ajacicyathus ex. gr. anabarensis (Vologdin) have been recorded (KALENIĆ, 1966).

Through the Poréc Zone of eastern Serbia, the Stara Planina Zone extends northwards, across the Danube, into the Danubian of the South Carpathians.

A highly controversial problem is represented by the existence, or the inexistence, of a "green" Vendian-Cambrian lithostratigraphic unit in the Danubian Realm.

Just north of the Danube, a mafic "Corbu formation" was thought to be an equivalent of the DPF: chlorite-albite-epidote, actinolite, quartz-chlorite-sericite-

graphite, quartz-albite-sericite and muscovite-garnet schists, with porphyroids and carbonatic lenticular intercalations (CODARCEA, CODARCEA—DESSILA, 1968). Recent research (MĂRUNȚIU, SEGHEDI, 1983; STAN, 1984) has shown that these rocks do not represent a distinct lithostratigraphic unit, being in fact plagiogneisses and micaschists with staurolitic and andalusite, amphibolites and amphibole gneiss of another Carpian Group (Neamțu), intensively retrogressed along an overthrust line of Early Caledonian age.

Further north, in the Vulcan, Parîng and Retezat Mountains, another "green" series (Clastic series, MANOLESCU, 1937; Upper Drăgșanu "Series", PAVELESCU, 1953; Vulcan "Series", SAVU *et al.*, 1978) had been separated, consisting of sericite-chlorite-epidote, chlorite-albite, actinolite and garnet-muscovite schists, porphyroids and limestones; their age should have been Cambrian. The same rocks are considered by BERZA (1975) as resulted by a Paleozoic retrogression from the Precambrian Drăgșanu Amphibolite Group.

In the northern part of the Retezat-Petreanu Mountains, the Zeicani Formation (GHERASI, DIMITRESCU 1968; GHERASI *et al.*, 1968) was also considered as Cambrian. It consists of a lower member of amphibole- and chlorite-albite-epidote-calcite-muscovite ± biotite schists (basic metatuffs), with sills of metagabbros and serpentinites, a median member of muscovite gneisses (metagreywackes) and an upper member of basic tuffogenic greenschists and metakeratophyric porphyroids (GHERASI, ZIMMERMANN, unpublished data). The Early Cambrian age assigned to the lower member is claimed to be supported by Protomycterosphaeridium marmoratum, occurring together with long ranging palynomorphs (GHERASI *et al.*, 1973), whereas the sporomorph assemblage of the upper member with Ellipsoidomorphids such as Acanthodiacrodium and Trachyzonodiacrodium (VISARION, SOLOMON, 1974) points to a Middle-Late Cambrian age.

All Danubian pre-Variscan formations are intruded by a great number of granitoid plutons the radiometric ages of which span between the Late Precambrian and the Lower Paleozoic.

b) Variscan (Tulișa Group). The Carpian highly metamorphic basement of the South Vulcan-Culmea Cernei Mountains is transgressively overlain by the Valea Izvorului Formation. A stratigraphic and metamorphic discordance is conspicuous at the basis of quartzites and sericitic metaconglomerates, followed by chlorite-, sericite- and graphite-phyllites. The first and only macrofauna of metamorphic rocks from Romania was discovered at Cloșani (STĂNOIU, 1971); it includes: *Favosites* sp., *Halysites* sp., *Cyathophyllum* sp., *Fenestella?* sp., *Plectorthinae, Dalmanellidae, Dolerorthis* sp., *Eoplectodonta* sp., *Ygerodiscus aff. undulatus, Leptaena* sp., *Leangella* sp., *Atrypina aff. barrandei, Atrypa cf. reticularis, Coelospira aff. hemisphaerica, Enricnurus* sp., *Flexicalymene* sp., *Caleidocrinus aff. artifex*. Conspicuously absent are the Spiriferida and Productida. According to this macrofauna the Valea Izvorului Formation has to be ascribed to the Upper Ordovician, grading perhaps into the Lower Silurian.

The basement of the Valea Izvorului Formation has a palynological assemblage including *Protoleiosphaeridium cambriense* and *Tyloligotriletum asper* (STĂNOIU, 1972). Its top is overlain by the transgressive Tusu Formation, which frequently overlies directly the Carpian basement. It is built up of metaconglomerates, quartzites and graphite- or chloritoid-phyllites. According to palaeofloral forms (STĂNOIU, 1980), the Tusu Formation is ascribed to the Devonian.

In the southern-eastern Banat an Ordovician-Silurian age is ascribed to the volcano-sedimentary Rîul Alb Formation (metaconglomerates, metasandstones, sericite-chlorite-quartz phyllites, metabasites and basic metatuffs; total thickness 1300 m) (NĂSTĂSEANU, 1975).

2) Getic Realm

a) Marisian. In the Kucaj Zone of eastern Serbia, Ordovician sandstones and phyllites are unconformably underlain by a metamorphic formation assumed to be an equivalent of the DPF of Bulgaria, and Riphaean-Early Cambrian in age.

North of the Danube, in different regions belonging to the Getic Realm (southern Semenic Mountains, southern Poiana Ruscă, northern Sebeş Mountains, eastern Cibin Mountains), the subjacent highly metamorphic Carpian Lotru Group is covered in discordance by the Cibin Group. It lithostratigraphic sequence was synthesized by KRÄUTNER (1980 *b*) as follows: 1) basic volcano-sedimentary formation, with a lower amphibolitic member and an upper metapryoclastic or metaterrigenic member; 2) carbonatic formation with graphitic schists; 3) blastodetrital formation. In different areas of the South Carpathians, this Group was described as Miniş-Buceava Series (CODARCEA, 1940; STRECKEISEN, 1934; SAVU, 1973), Dăbîca Series (MAIER *et al.*, 1975), Căpîlna-Cărpiniş Series (CHIVU, 1970, 1979) and Sibişel Series (CODARCEA—DESSILA, 1965). All the mentioned sequences have been metamorphosed in greenschist facies (almandine zone) and display a Variscan retrogression. Their palynomorph assemblages include mainly ultramicrospores and Sphaeromorphids ranging from the Late Proterozoic to the Cambrian, together with *Protoleiosphaeridium cambriense, Trachydiacrodium* and *Protomycterosphaeridium marmoratum* (DESSILA—CODARCEA, ILIESCU, 1967), allowing to assign at least the top of the Cibin Group to the Cambrian.

There are no Variscan formations overlying the Cibin Group.

The Miniş-Buceava "Series", together with its Carpian basement (Lotru Group) are intruded by the Sichevița-Poniasca pluton.

3) Supragetic Realm

Western Supragetic Unit (Banat)

a) Marisian. In the inner part of the Serbo-Macedonian massif there are several "epimetamorphic" rock sequences considered to be Late Precambrian to Early Cambrian in age. On of them is the Vlasina "Complex" from the central part of the Morava Zone.

b) Variscan. In the same Morava Zone, the next younger formation, transgressive over the Vlasina Formation or the DPF, is built up of sericite-quartz phyllites and green metasandstones, with intercalated metaspilites, metadiabases and metagabbros. A Tremadocian fauna includes *Obolus feistmanteli* or *O. barrandei, O. complexus* or *Orbiculoidea* sp.

In the western Banat, the Locva Formation may be divided into two members. The lower member consists of muscovite-chlorite (±microcline) gneisses predominating over chlorite-muscovite-albite, quartz- and actinolite-schists. The upper member includes muscovite-chlorite schists with albite porphyroblasts interbedded with albite-chlorite-calcite, actinolite-chlorite-epidote schists and quartzites (Maier, 1974).

The palynologic assemblage of this formation (MAIER, VISARION, 1976) includes *Leiosphaeridae, Pseudozonosphaeridiae, Lophosphaeridium* sp., *Acanthodiacrodium* sp., *Leiofusa* sp., *Veryhachium* sp., *Schizmatosphaeridium* sp., *Navifusa* sp., as well as Chitinozoans *(Conochitina, Clathrochitina, Desmochitina);* its age seems accord-

ingly to be Ordovician (supposedly raising to the Silurian, but possibly beginning in the Cambrian).

The origin of the Locva Formation has to be sought in a terrigene material, of greywacke nature mixed with basic tuffs. The first metamorphism, of medium grade and Caledonian in age, produced oligoclase, garnet and biotite; it was followed by a Variscan retrogression, transforming the above minerals in albite, chlorite, sericite and calcite.

The Locva Formation is overlain by the Leşcoviţa Formation (MAIER, 1974) beginning with leptynites, metadacitic porphyroids, epidote-chlorite-actinolite-albite schists (basic metatuffs), metadolerites and terrigenic quartz-muscovite schists. The palynological assemblage includes Acritarchs, Scolenodonts, Chitinozoans *(Lagenochitina, Conochitina, Angochitina), Verrucosisporites grandis, Punctatisporites* sp., *Stenozonotriletes* sp., and points to an Early-Medium Devonian age (MAIER, VISARION, 1976).

Eastern Supragetic Unit
Făgăraş-Ezer-Leaota Mountains)

a) Marisian. The Vendian and perhaps a part of the Cambrian are probably included în the Lereşti Formation (1500—3000 m). It consists mainly of muscovite-chlorite schists with albite porphyroblasts, of probable greywackean origin, with intercalations of chlorite-albite greenschists (basic metatuffs), amphibolites, graphite schists and dolomites. An upper member of the Lereşti Formation consists of quartz-albite (±microcline) schists, with a few muscovite and chlorite flakes. The metamorphism of the Lereşti Formation developed in the greenschist facies, partly in the almandine zone and partly in the chlorite zone. The sedimentation age is not directly known, but by lithologic comparison with the Biharia Formation it may be inferred as Upper Proterozoic (DIMITRESCU, 1978).

b) Variscan. In the eastern part of the Făgăraş Massif (Păpuşa Mountains) the Lereşti Formation is overlain by the probably transgressive Căluşu Formation (chlorite-sericite-albite, chlorite-actinolite-albite, sericite-quartz and graphite schists, scarce acid metatuffs) which yields Palaeozoic (up to Lower Carboniferous) microspores.

No granitic rocks intrude the Căluşu Formation. The Lereşti Formation, by contrast, is intruded by vein-like bodies of red Lalu Granite, the age of which is still unclear. In the basement of the Lereşti Formation sills of Albeşti Granites are known, with three K-Ar ages of 464, 475 and 477 m.y. (DIMITRESCU, 1978; POPOVICI, 1978).

4) Eastern Carpathians: Bucovinian nappe system

a) Marisian. In the East Carpathians, the main lithostratigraphic unit is represented by the Marisian Tulgheş Group. It consists of five formations: Tg_1 Blastodetrital-Quartzitic Formation; Tg_2 Graphite-Metalyditic Formation; Tg_3 Volcano-Sedimentary Metarhyolitic Formation; Tg_4 Blastodetrital-Phyllitic Formation; Tg_5 Graphitic-Greenschist-Carbonatic Formation. The whole group was metamorphosed in the greenschist facies, reaching locally the biotite zone (BERCIA *et al.*, 1976).

Four types of palynomorph assemblages were recognized in the Tulgheş Group: 1) Acritarchs of the types *Baltisphaeridium, Cymatiosphaerea* and *Veryhachium*, considered to make their first appearance in the Cambrian; 2) Acritarchs characteristic of the Lower Cambrian *(Granomarginata vulgaris, Acantosphaera cambriensis,*

Microconcentrica atava, Spumosata prima; 3) Sphaeromorpha common to the Vendian and Lower Cambrian: *Archaeopsophosphaera asperata, Archaeosacculina* sp., *Granomarginata cf. squamacea, Trachypsophosphaera exilis, Trachysphaeridium incrassatum, T. atenuatum;* 4) Sphaeromorphs covering most of the Middle and Late Proterozoic and declining in the Lower Cambrian *(Protosphaeridium flexuosum, P. acis, P. tuberculiferum, P. laccatum, Orygmatosphaeridium distributum, Asperatopsophosphaera* sp., *Archaeofavosina* sp., *Podoliella irregulare)* (ILIESCU *et al.*, 1983).

The Tg_1 Formation represents, according to ILIESCU, MURESAN (1972), ILIESCU *et al.* (1983) the Lower Cambrian and possibly also the Upper Vendian. For the upper part of the Tulgheş Group (Tg_4 and Tg_5 formations), a Middle Cambrian age at least may be supposed, but the Upper Cambrian and possibly the Lowest Ordovician may also be included in the sequence (ILIESCU *et al.*, 1983), especially according to the forms *Leiomesotriletes, Stenomesotriletes* found by ONICEANU *et al.* (1977).

The available radiometric ages of rocks constituting the Tulgheş Group are the following: U-Pb zircon ages of 560—640 m.y. (BOIKO *et al.*, 1974), Pb-Pb ages 540—600 m.y. on syngenetic stratiform ores in the Tg_3 Formation (VÎJDEA, ANASTASE in MÎNZATU *et al.*, 1975 and unpublished data; POPESCU, unpublished data), K/Ar whole rock and sericite ages with maximal values of 475 m.y. (K/Ar isochrone age of 505 ± 5 m.y., KRÄUTNER *et al.*, 1976).

b) Variscan. In the western Rodna Mountains, the Carpian Bretila Group is overlain in transgression by the Repedea Formation (KRÄUTNER, 1968). It consists of a lower member Rp_1 with greenschists (basic metatuffs) and sericite-chlorite-chloritoid schists and an upper member Rp_2 built up of metaconglomerates, graphitic quartzites, sericite-chlorite schists and limestones. The age is Late Ordovician-Silurian, according to the palynologic assemblage of the Rp_2 member *(Bursachitina* sp., *Lagenochitina macrostoma, Desmochitina congulata, Sphaerochitina* sp., *Chonochitina lagenomorpha, Leiotriletes* sp., *Retusotriletes* sp.*)*, characteristic of the Ludlovian.

A slight Late Caledonian premetamorphic discordance separates the Repedea Formation from the overlying Cimpoiasa Formation (Devonian, according to its palynomorph assemblage; ILIESCU, KRÄUTNER, 1976).

In the eastern Rodna Mountains, the place of the Repedea Formation is taken by the Rusaia Formation. Beginning with metaconglomerates, limestones and quartzites, it continues with chlorite schists, the top being built up of dolomites and carbonatic schists. Besides common Silurian-Devonian forms *(Bursachitina cf. urna, Leiotriletes* sp., *Leptotriletes* sp., *Achantotriletes* sp., *Archaeozonotriletes* sp., *Pterospumopsis* sp., *Protosphaeridium cf. microgunifer, Multiplicisphaeridium* sp., *M. cf. lobezum),* the palynomorph assemblage (ILIESCU, KRÄUTNER, 1978) includes *Lophosphaeridium* sp., *Baltisphaeridium* sp., *Synsphaeridium* sp., *S. conglutinatum, Zonosphaeridium* sp., *Leiosphaeridium* sp., *Trachysphaeridium* sp., which do not transgress the Silurian-Devonian boundary; the age has accordingly to be ascribed to the Silurian (including perhaps the Late Ordovician).

There are no granitic intrusions either in the Variscan or in the Marisian of the East Carpathians.

III INTERNAL DACIDES

5) Apuseni Mountains

a) Marisian. The Bihor Autochthon of the Northern Apuseni Mountains has a very large sole of crystalline schists, the upper part of which is built up of the Arada Formation (3000 m) (DIMITRESCU, 1966). It consists mainly of sericite-chlorite

schists in which persistent intercalations are represented by sericite-chlorite-albite, chlorite-epidote and albite-actinolite-epidote schists (basic metatuffs±metagraywackes), porphyroids (metarhyolitic welded tuffs), hälleflinta (acid metatuffs), graphite quartzites (metalydites) and a single layer of crystalline dolomitic limestone.

The polynomorph assemblage of the Arada Formation includes common Vendian-Lower Cambrian forms *(Protosphaeridium* sp., *Pr. cf. acis, Kildinella* sp., *Laminarites* sp., *Favososphaeridium* sp., *Orygmatosphaeridium* sp., *Pseudozonosphaeridium* sp., *Asperatopsophosphaera* sp., *Leiospshaeridia* sp., *Synsphaeridium* sp., and in addition *Pr. flexuosum (M. marmoratum)* (Cambrian) (VISARION, DIMITRESCU, 1971; VISARION, unpublished data).

The metamorphism of the Arada Formation corresponds to the low-grade or to the greenschist facies. A biotite (+oligoclase) and a chlorite isograd have been traced. However, the formation is polymetamorphic, the retrogression being evident in the biotite zone only, by the chloritization of biotites and amphiboles. Both the Someş and the Arada formations are intruded by the Muntele Mare granitic massif, which yielded, besides Alpine and Variscan ages, on K-Ar age of 522 m.y.

The Bihor "Autochthon" underlies the Codru Nappe System covered itself by the Biharia Nappe System. The crystalline basement of the latter consists of the Biharia and the Muncel formations.

The Biharia Formation (1000 m) is mainly built up of chlorite-albite, chlorite-epidote-calcite and actinolite-epidote-albite schists (basic metavolcanogenic rocks), alternating with muscovite-chlorite-quartz-albite schists; two thin intercalations of dolomitic limestone are known (DIMITRESCU, 1976). Another characteristic element is represented by small bodies of orthoamphibolites (metagabbros, metadiorites, metadolerites). Locally metatrondhjemites are associated. Its metamorphism is generally of lowgrade (greenschist facies) in the chlorite zone, but occasionally biotite and garnet appear (epidote-amphibolite subfacies).

The palynomorph assemblage of the Biharia Formation *(Protosphaeridium* sp., *Pr. flexuosum, Pr. cf. acis, Kildinella* sp., *Laminarites* sp., *Favososphaeridium* sp., *Orygmatosphaeridium* sp., *Pseudozonosphaeridium* sp., *Ps. cf. populosum, Asperatopsophosphaera* sp., *Leiosphaeridia* sp., *Synsphaeridium* sp.*)* supports only a Late Proterozoic (Vendian) age.

The Biharia Formation grades upwards into the Muncel Formation (1500 m). The lower member of the latter (200—500 m), considered by some as an upper member of the Biharia Formation, consists of sericite-chlorite, sericite-albite, chlorite-albite and quartz-albite schists (DIMITRESCU, 1976). Its palynomorph assemblage includes *Protosphaeridium flexuosum (M. marmoratum), Uniporata nitidus, Spumosata nova, Polyporata verrucosa, Margaporata glabella,* common Vendian-Early Cambrian forms, along with *Veryhachium balticum, Polyedrixium prituli, Archaeohystrichosphaeridium pungens,* allowing its ascribing to the Lower-Middle Cambrian (VISARION, DIMITRESCU, 1971; SOLOMON *et al.*, 1984). The middle member of the Muncel Formation (300—1000 m) consists of sericite schists with intercalations of metarhyolitic porphyroids and of augen gneisses. The upper member (500—700 m) begins with graphite quartzites and continues with biotite-sericite schists, biotite paragneisses, amphibole schists and metarhyolitic biotite porphyroids. The palynological assemblage (VISARION, DIMITRESCU, 1971; VISARION, unpublished data) including *Leiosphaeridia cf. dehisca, Cymatiosphaera* sp., *Acanthodiacrodium* sp., *Trachydiacrodium cf. signatum, Baltisphaeridium* sp., *B. cf. papillosum, Lagenochitina* sp., *Scolecodonta* sp., is more definite Cambrian in age, including the Upper Cambrian and perhaps even a part of the Ordovician.

The metamorphism of the Muncel Formation is low-grade (chlorite isograde), excepting the upper part that overpasses the biotite and even the almandine isograde.

Comparing the lithostratigraphic sequences in the Bihor "Autochthon" and in the nappes, a close affinity may be observed between the Arada Formation on the one hand and the Biharia and Muncel Formations on the other hand. In both realms, an acid magmatism follows or is associated to a basic one. The palynological contents are similar.

b) Variscan. In the Codru and Biharia Nappe Systems of the northern Apuseni Mountains, the Biharia Formation is transgressively overlain by the Păiuşeni Formation. The lower member of the latter is built up of sericite-metaconglomerates, quartzites, sericite-chlorite schists, scarce limestones; in the upper member, chlorite-albite schists, actinolite schists, metakeratophyric porphyroids and carbonatic schists predominate. The palynologic assemblage of the lower member includes, in the Highiş Mountains (VISARION, in ISTOCESCU, 1971), *Stenozonotriletes simplicissimus, Leiotriletes microrugosus, Zonotriletes cf. auritus,* pointing to a Late Devonian age (the upper member being proved as Early Carboniferous).

The Păiuşeni Formation is intruded by the Variscan Highiş Granite.

CONCLUSIONS

Similarly to the Alps, a Caledonian event has to be recognized in the Carpathians. This does not mean that a direct link with the Caledonides of Scandinavia has already been demonstrated.

The main proof of the Caledonian event consists in the break of sedimentation, post-dating an older metamorphism of formations belonging to the lower structural stage, occurring at some point during the Ordovician, thus dividing the Variscan from the Marisian. The Valea Isvorului, Leşcoviţa, Repedea-Rusaia and Păiuşeni formations overlie a basement built up sometimes of Carpian and sometimes of Marisian formations. The proved Cambrian (—Early Ordovician?) age of the latter diminishes the time-gap between themselves and the basis of the Variscan transgression, taking place at the earliest moment in the Late Ordovician.

Between the two groups, as seen from the previous descriptions, there is almost always a difference in metamorphic degree, the Variscan being naturally less metamorphosed. Metaconglomerates are very frequent at the basis of the Variscan pile.

A granitoid plutonism, conspicuously absent from the Variscan (with the exception of the Apuseni Mts) intrudes the Carpian and its Marisian cover: Muntele Mare massif in the Apuseni Mts, Sicheviţa-Poniasca massif in the Banat, Danubian. The isotopic ages of some of these granites are Caledonian.

In the Carpian formations themselves (older elements within the Caledonian) a number of 40—50 radiometric ages between 400—500 m.y. suggest an Early Caledonian thermal event.

Structural analysis of Marisian rocks yielded a last deformation phase F_3 attributed to the Variscan. By contrast, the structural analysis of the Variscan formations revealed less metamorphic episodes.

A basic (ophiolitic?) suite is recognizable almost everywhere within the Marisian, as a prelude of the Caledonian event. By contrast, there is no clear separation between an acidic volcanism postdating this event and a basic volcanism, which can be considered as initiating the Variscan orogeny.

Later Caledonian events (*e.g.* the slight discordance of the Devonian Cimpoiasa overlying the Repedea Formation) are devoid of metamorphic phenomena, having thus a minor importance.

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